

Altruistic Behavior in Supply Chain Management

By R. BOUTE and M. LAMBRECHT



Robert Boute
Operations & Technology Management
Centre Vlerick Leuven, Gent
Management School



Marc Lambrecht
Research Center for Operations
Management
Department of Decision Sciences
and Information Management
(K.U.Leuven)

ABSTRACT

Supply chain collaboration creates a gain (a surplus) compared to uncoordinated or disconnected supply chain policies. In this paper we review policies to allocate the “gain” to supply chain members so that each firm’s objective becomes aligned with the supply chain’s objective. In other words we examine conditions for a successful implementation of “altruistic” behavior (that means a policy that is not optimal for itself, but optimal for global performance). Several policies are examined, such as alignment of replenishment rules, vendor managed inventory, buyback contracts, revenue sharing contracts and quantity discount contracts.

I. INTRODUCTION

Supply chains can be viewed as networks or consortia of firms that are pooling their capabilities and resources. These industry or service networks consist of focused specialists. It is clear that in such an environment there is an increased need for supply chain coordination. Modern supply chain management starts with the premise that supply chain members are primarily concerned with optimizing their own objectives and that self-serving focus often results in poor performance, or a sequence of locally optimal policies does not bring a globally optimal solution (Cachon 2003). Munson et al. (2003) summarize it as follows “When each member of a group tries to maximize his or her own benefit without regard to the impact on other members of the group, the overall effectiveness may suffer. Such inefficiencies often creep in when rational members of supply chains optimize individually instead of coordinating their efforts”.

This premise does have a number of important consequences. One of them is that at least one player in a supply chain network should display altruistic behavior, that means, pursuing a policy that is not optimal for itself, but optimal for the global performance. This explains the title of this review article. How can somebody achieve that each firm’s objective becomes aligned with the supply chain’s objective? We must also make sure that the supply chain actions should be a unique Nash equilibrium, we should not coordinate on a suboptimal set of actions and no firm should have a profitable unilateral deviation from the optimal global supply chain actions.

The success of the altruistic behavior depends on what is done with the supply chain gain. The supply chain gain can be defined as the difference in profit between a coordinated and an uncoordinated supply chain policy. Coordination creates a surplus, a supply chain gain as it is called. This gain has to be allocated to the individual members of the network. This allocation can take the form of a transfer payment that ensures that each firm’s objective becomes aligned with the supply chain’s objective. That is the key idea of this paper.

This paper is organized as follows. In section II, we review several supply chain gain allocation policies such as: buyback contracts, revenue-sharing contracts, quantity flexibility contracts, sales rebate contracts and quantity discounts contracts. In section III, we suggest a method to improve supply chain performance by coordinating, or aligning, the parameters of replenishment rules used in supply chain

management. A well known practical implementation of such a policy, namely, Vendor Managed Inventory (VMI) will be discussed. Section IV draws some conclusions.

II. SUPPLY CHAIN CONTRACTING

As was mentioned in the introduction, supply chain coordination may create a surplus or a gain. That means that companies are better off when they act as a group instead of individually. If a supplier and a retailer work together (through information sharing, collaborative forecasting, joint replenishment, etc.) suppliers may realize economies of scale in the production and the distribution process. In return, retailers may transfer inventory carrying costs to the supplier. The capital cost of carrying inventory is transferred simply by having the retailer pay the supplier only when the items are sold. Bernstein et al. (2006) report on the Wal-Mart policy where they want their vendors to capture the Point-Of-Sales transaction which says: it's been bought, so now you can bill Wal-Mart. Even physical warehousing costs are sometimes transferred by suppliers or their third-party logistics providers owning or renting warehouse space in the proximity of the retailers. These partnerships often require major investments in information sharing technology. This example illustrates the need to develop a theory of the economics of supply chain integration.

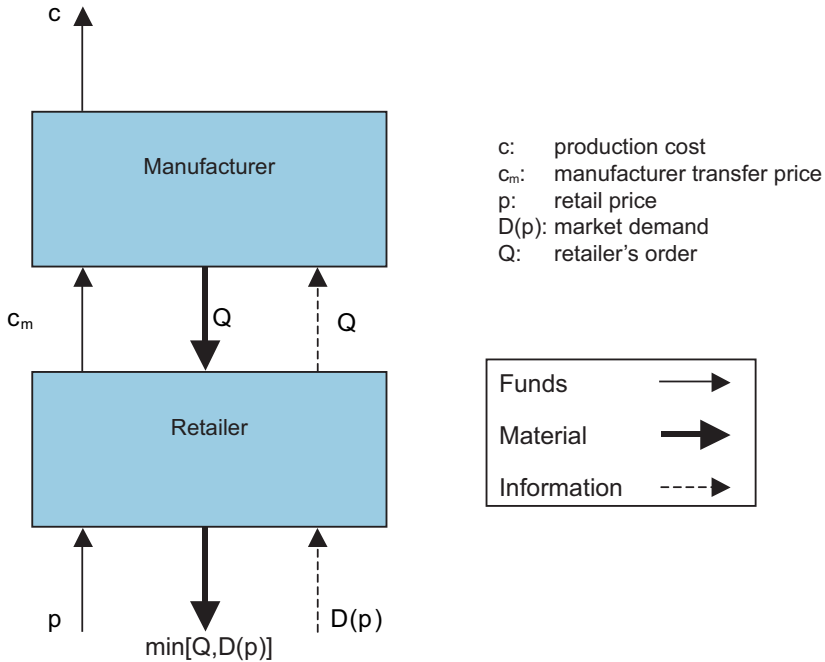
Recently researchers started to model these contracting issues. The objective of this section is to review a number of these models.

A. *The Newsvendor Problem*

Throughout the text, we will use a simple supply chain structure based on Tsay et al. (1999). Consider a supply chain with two echelons, a retailer and a manufacturer (see Figure 1). The manufacturer produces the product at a constant unit cost, c , and charges the retailer a unit manufacturer transfer price denoted by c_m . The retailer sells the product at a price of p per unit. Market demand denoted by $D(p)$ is price sensitive and uncertain. Unsold products still have a certain value, called salvage value v . The retailer's order quantity is denoted by Q . This problem is usually studied in a so-called newsvendor setting.

A newsvendor problem is a one-period problem in which the retailer (buyer) must make a single bet (that means determining the order

FIGURE 1
Two echelon supply chain structure (based on Tsay et al. 1999)



quantity) before a random demand occurs (you may think of fashion products, short life cycle products,...). There are costs if the bet turns out to be too high (overstocking cost). There are costs if the bet turns out to be too low (understocking cost). The newsvendor model's objective is to bet an amount that correctly balances those opposing forces. It is clear that the manufacturer is bounded by the decision made by the retailer. This setting introduces some simplifying assumptions, but it still captures a real world situation and it makes the analysis more tractable.

The above situation can now be analyzed with a decentralized control structure (the retailer and manufacturer determine the optimal decisions independently) or with a coordination control structure (e.g. a risk-sharing arrangement or assuming that all decisions are made by a single decision maker). The difference between the expected profits under both scenarios is called the supply chain gain. The allocation of the gain among the supply chain members can be the subject of a supply chain contract.

Consider the retailer's problem. The retailer's order quantity Q fully depends on the optimal balance of the overstocking and understocking cost. The overstocking cost equals $C_{ov} = (c_m - v)$ and the understocking cost equals $C_{un} = (p - c_m)$. It can be shown that the economic stockout probability $\Pr(D \geq Q)$ is determined by:

$$\Pr(D \geq Q) = \frac{C_{ov}}{C_{un} + C_{ov}} \quad (1)$$

Once the order quantity Q is determined by the retailer by using (1), the manufacturer is assumed to correctly anticipate how the retailer will order. The manufacturer is bounded by the decision of the retailer and the manufacturer's profit is deterministic. It is interesting to note that all uncertainty regarding channel profits is foisted onto the retailer.

We will now look for mechanisms that the supply chain parties can use to improve profits (and consequently create a supply chain gain). One possibility is to offer a buy-back contract. In such a contract, the manufacturer agrees to buy back unsold goods from the retailer for some agreed-upon price. If the buyback price, b , is larger than the salvage value, then the overstocking cost will decrease. This will result in an increase of the order quantity of the retailer. The buy-back contract is effective because it allows the manufacturer to share some of the risk with the retailer and thus motivates the retailer to increase the order quantity. With a buy-back contract the manufacturer is now exposed to the possibility of a poor (unfavorable) demand outcome. A buy-back contract is an example of a coordinating contract. There are many other coordinating contracts, e.g. a revenue-sharing contract. In a revenue-sharing contract, the retailer shares some of the revenue with the manufacturer in return for a discount on the transfer price c_m . Note that a coordinating contract is not unique. Contracts differ in how they divide the additional channel profit among the players.

Quantity flexibility contract is another coordination scheme. In a quantity flexibility contract, the manufacturer provides an "upside" coverage to the retailer of $u\%$ above the initial order. In return, the retailer accepts a "downside" commitment of $d\%$. The retailer commits him/herself to a minimum purchase requirement. The retailer is allowed to cancel $d\%$ of the order but must take the remainder.

Another common type of coordinating scheme are quantity discounts. Quantity discounts encourage buyers to order additional inventory because the purchase price of the last unit purchased is decreasing

with the amount purchased. In other words it has an impact on c_m (and consequently increases the understocking cost) (see section B).

It is amazing to observe that the one period newsvendor problem offers the methodological basis to study various types of coordinating contracts. The newsvendor parameters are different for each type of coordinating contract. These parameter values determine the critical ratio or economic stock-out probability. And this in turn determines the order quantity.

B. *Quantity and volume discounts*

In an environment where the price is set by the market, manufacturers can use lot size based quantity discounts to achieve coordination in the supply chain and for products where the firm has market power, volume based quantity discounts can be used to achieve coordination and to maximize supply chain profits (Chopra and Meindl, 2007).

Let's first discuss the issue of lot size based quantity discounts. This type of coordinating scheme is common practice in industry and retailing. A manufacturer (supplier) reduces the unit price if the buyer (retailer) buys more than a certain number of units in one lot. How can such a policy coordinate decisions made by supply chain partners?

Assume that a retailer wants to order in batch sizes of Q_r units. The manufacturer however prefers, based on his production economics, to produce in batches of Q_m units. Here we clearly have a conflict. It may therefore be advisable to find a batch size which is minimizing total ordering and inventory costs for both parties simultaneously. This so-called coordinated economic order quantity Q_{co} can easily be computed (see e.g. Lambrecht 2006). Many scenarios are possible, but assume that:

$$Q_r \leq Q_{co} \leq Q_m \quad (2)$$

Imposing Q_{co} on both supply chain partners is clearly disadvantageous for the retailer. The manufacturer however experiences a gain (the coordinated lot size is closer to his preferred batch size), let's denote the gain by $\Delta_{coordinated}$. Let's denote the extra supply chain cost for the retailer by $\Theta_{retailer}$. The retailer will only be willing to give up his preferred lot size if his loss $\Theta_{retailer}$ is compensated by the manufacturer. Part of $\Delta_{coordinated}$ can now be used as a "transfer"

payment to compensate for the loss of the retailer. This transfer payment can take on the form of a quantity discount. The discount will be offered for lot sizes of Q_{co} . In this way, the decisions of both supply chain members will be aligned and the supply chain gain will be realized.

Let's now turn to the situation where the retailer has market power. We now assume a demand curve $D(p)$. The fundamental decision is to determine p (retailer price). The existence of two entities (retailer and manufacturer) in the supply chain can lead to *double marginalization*. Double marginalization refers to the notion where each supply chain member sets its price independently. The manufacturer fixes a transfer price c_m for the retailer and in turn the retailer determines a selling price p . Double marginalization is a well-known cause of supply chain inefficiency, it leads to a loss in profit because each stage makes its decision considering only its local margin (Chopra and Meindl, 2007). It is possible to find a unique retailer price p_{co} , a globally optimal, coordinated price which will maximize the overall supply chain profit. This price usually results in a higher sales volume. In order to align the decisions of the supply chain partners, it may be required to allocate the supply chain gain. This can be achieved by offering a volume-based quantity discount (and consequently lowering c_m) to the retailer. The above reasoning holds under the assumption that customer demand increases when the retailer decreases the price.

All of the examples discussed in this section deal with vertical coordination. This results in contracts between upstream and downstream members of the same supply chain. What is common to all of these agreements? Two elements are crucial, one, the risk sharing motive and two, the necessary condition that all parties ultimately benefit. There are of course a large number of other coordinating mechanisms for firms e.g. belonging to different supply chains. This is usually referred to as horizontal coordination. Think of spare part management agreements between airline companies, the exploitation of common warehouse facilities, optimization of (multi-modal) transportation, etc. The main purpose of these horizontal coordination mechanisms is to improve efficiency through the exploitation of economies of scale. In this article, we do not further discuss horizontal coordination, instead we will focus in the next section on the creation of a transparent, visible demand pattern that paces the (entire) supply chain through the alignment of replenishment rules.

III. ALIGNING REPLENISHMENT RULES

A. *A win-win solution for the bullwhip problem*

Lack of coordination in supply chains may lead to serious supply chain problems. One of these problems is the bullwhip effect. This effect refers to the tendency of replenishment orders to increase in variability as one moves up the supply chain from retailer to manufacturer. Procter and Gamble used this terminology to describe the ordering behavior witnessed between customers and suppliers of Pampers diapers. While diapers enjoy a fairly constant consumption rate, P&G found that wholesale orders tended to fluctuate considerably over time. They observed further amplification of the oscillations of orders placed to their suppliers of raw material. This distorted information throughout the supply chain can lead to tremendous inefficiencies; excessive inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation, and missed production schedules (Lee et al. 1997).

It has been recognized that the ordering policy used by the members of the chain is one of the key causes of the bullwhip effect (Dejonckheere et al. 2003). In other words, when supply chain members are primarily focussed on optimizing their own inventory policy, the bullwhip effect may occur, resulting in significant cost implications for the supply chain partners, and as such, leading to a poor overall supply chain performance. Therefore, in order to achieve the global supply chain's objective, taming the bullwhip seems to be a dominating strategy. This can be done by aligning the replenishment policy with the supply chain partners. The upstream manufacturer aims to smooth production and therefore he prefers minimal variability in the replenishment orders from the (downstream) retailer. The manufacturer not only prefers a level production schedule, the smoothed demand also allows him to minimize his raw materials inventory cost. Balakrishnan et al. (2004) emphasize the opportunities to reduce supply chain costs by dampening order variability.

This has led to the creation of new replenishment rules that are able to generate *smooth* order patterns (e.g. Dejonckheere et al. 2003, Balakrishnan et al. 2004). This implies that supply chain members display altruistic behavior by reducing the variability in their replenishment orders to serve the global performance. However, the upstream echelons do benefit from smooth replenishments, but the downstream

echelons may have a negative impact on customer service due to inventory variance increases. Disney et al. (2006) quantify the variance of the net stock and compute the required safety stock as a function of the smoothing intensity. Their main conclusion is that when customer demand is i.i.d.(independently and identically distributed), order smoothing comes at a price. In order to guarantee the same fill rate, more investment in safety stock is required (see also Disney et al. 2005).

Let us focus on a replenishment rule that is able to smooth the order pattern. Given the common practice in retailing to replenish inventories frequently (e.g. daily) and the tendency of manufacturers to produce to demand, we focus on periodic review, base-stock or order-up-to replenishment policies. The standard periodic review base-stock replenishment policy is the (R,S) replenishment policy. At the end of every review period R, the retailer tracks his inventory position IP_t , which is the sum of the inventory on hand (items immediately available to meet demand) and the inventory on order (items ordered but not yet arrived due to the lead time) minus the backlog (demand that could not be fulfilled and still has to be delivered). A replenishment order is then placed to raise the inventory position to an order-up-to or base-stock level S, which determines the order quantity O_t :

$$O_t = S - IP_t. \quad (3)$$

A *smoothing* replenishment policy is a policy where the decision maker does not recover the entire deficit between the base-stock level and the inventory position in one time period (contrary to what happens in Eqn. (3)). Forrester (1961) proposes to order only a fraction β of the inventory deficit, resulting in the following ordering policy:

$$O_t = \beta \cdot (S - IP_t). \quad (4)$$

Forrester (1961) refers to $1/\beta$ as the ‘adjustment time’ and hence explicitly acknowledges that the deficit recovery should be spread out over time. Under a fixed lead time assumption such a smoothing policy is justified when production (or ordering) and holding costs are convex or when there is a cost of changing the level of production. When lead times are considered to be endogenously determined, this replenishment rule smoothes the manufacturer’s production, resulting in shorter order-to-delivery times and more balanced production schedules.

To examine the variability in orders created by our smoothing rule, we look at the ratio of the variance of the orders over the variance of demand (in the literature this variance ratio is commonly used as a measure for the bullwhip effect), which is in this case given by

$$\frac{\text{Var}(O)}{\text{Var}(D)} = \frac{\beta}{2 - \beta}. \quad (5)$$

Hence, if we do not smooth, i.e. if $\beta = 1$, these expressions reduce to the standard base-stock policy, where $O_t = D_t$; we chase sales and thus there is no variance amplification. For $1 < \beta < 2$ we create bullwhip (variance amplification) and for $0 < \beta < 1$ we generate a smooth replenishment pattern (dampening order variability).

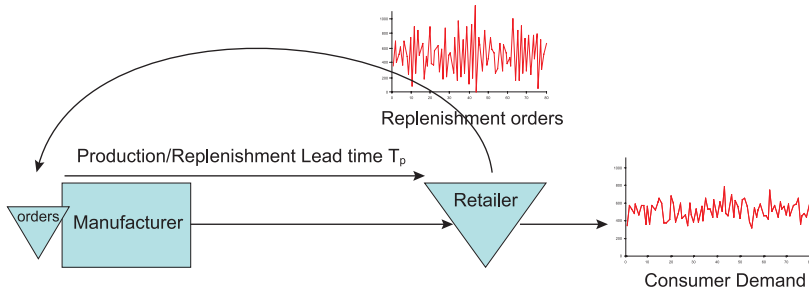
So far, we have been concentrating on the variance of orders placed. This is, however, only one side of the coin. We should also study the variance of inventory, because that variance will have an immediate effect on customer service: the higher the variance, the more stock will be needed to maintain customer service at the target level. We therefore measure the net stock amplification (NSAmp), which equals the ratio of the inventory variance over the demand variance. Net stock variance (let alone variance amplification) is not a common supply chain measure, but we need it to calculate the fill rate, which is a popular customer service measure. For the replenishment rule described by Eqn. (4), Disney et al. (2006) show that when demand is i.i.d., the net stock amplification is given by the following expression:

$$\text{NSAmp} = 1 + Tp + \frac{(1 - \beta)^2}{(2 - \beta)\beta}, \quad (6)$$

where Tp denotes the physical replenishment lead time. Eqn. (6) indeed indicates that both smooth ordering patterns and bullwhip result in higher inventory fluctuations compared to the standard order-up-to policy, and consequently they provide a poorer fill rate. In other words, we are able to smooth the order pattern, but pay the price of higher inventory fluctuations and more inventory costs.

This has an important consequence. Manufacturers do benefit from smooth production, but retailers, driven by the goal of reducing inventory (holding and shortage/backlog) costs, prefer to use replenishment policies that chase demand rather than dampen consumer demand variability. This leads to a tension between the preferred order variability

FIGURE 2
A two echelon supply chain model as a production/inventory system



of retailers and manufacturers and the globally optimal solution may not be reached.

This conflicting issue can be resolved by coordinating the supply chain. Boute (2006) models a two echelon supply chain as a production-inventory system, as illustrated in Figure 2. This implies that a replenishment order generated by the retailer's inventory results in an arrival of a production order at the manufacturer. Hence the choice of the retailer's replenishment policy (amplifying or dampening customer demand variability in the replenishment orders) determines the arrival process of production orders at the manufacturer's production queue and as such it affects the distribution of the lead times.

In this model, Boute (2006) demonstrates that a smooth order pattern generates shorter and less variable (production/replenishment) lead times, introducing a compensating effect on the inventory levels. This results in a win-win solution for all supply chain partners: smooth production upstream the chain *and* lower inventory levels downstream the supply chain. Hence, the buy-back contract discussed in the previous section takes in this case the form of a reduced delivery lead time.

B. *Supply chain coordination through Vendor Managed Inventories (VMI)*

In a traditional supply chain, each level in the supply chain issues production orders and replenishes stock without considering the situation at either up- or downstream tiers of the supply chain. This is how most

supply chains still operate, no formal collaboration between the retailer and the supplier. However, when supply chain members act like independent entities with individual goals, even if each of them behaves rationally, the entire chain would only be able to achieve a local optimum or a myopic profitability. In order to achieve the global supply chain optimum, collaboration can be installed through a wide range of concepts such as Collaborative Forecasting Planning and Replenishment (CPFR), Information Sharing and Vendor Managed Inventory (VMI, including Continuous Replenishment). A more drastic solution can be obtained by a redesign of the supply chain by eliminating echelons. One of the commonly used strategies for achieving supply chain coordination is the Vendor Managed Inventory method. In this section we discuss why the VMI model may be favorable over the traditional supply chain structure.

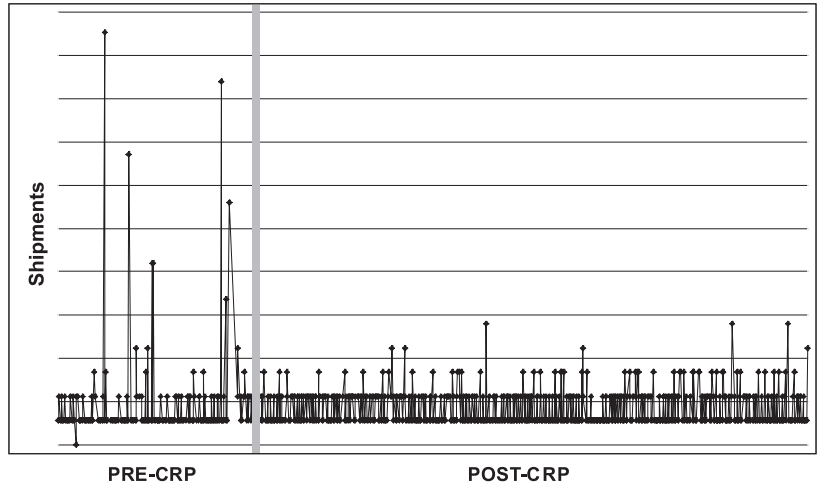
VMI eliminates one decision point and merges the replenishment decision with the production and materials planning of the supplier. Here, the supplier takes charge of the customer's inventory replenishment on the operational level, and uses this visibility in planning his own supply operations (e.g. more efficient production schedules and transportation planning). With VMI, multi-echelon supply chains can act in the same way, dynamically, as a single echelon of a supply chain. This allows the supplier to proactively plan his production and shipments to the customer, instead of reacting to the customer's orders. Additionally, the supplier has a much better market knowledge about his products than the retailer. Therefore he is in a better position for forecasting and inventory control purposes, resulting in improved inventory performance and customer service levels at every stage of the supply chain. VMI often results in more frequent replenishments and consequently the order quantity variance is reduced. Economies in transportation can also be obtained through an optimization of the route planning and with methods such as joint replenishment and inventory routing techniques. The VMI model is in other words a channel coordination strategy between downstream and upstream players. Based on their common interests and objectives, the two players reach an agreement that the upstream member will manage the downstream member's inventory stock decisions and that both will monitor and modify their agreed terms.

We briefly illustrate the benefits of VMI with a real life example. We analyze the ordering pattern of a bakery company focusing on authentic specialties in the biscuit and cake world: caramelized

biscuits, waffles, frangipane, and cake specialties among others. For certain products, a make-to-order policy is employed and the assumptions used in this paper are largely satisfied. In 2002, the firm introduced a VMI program implemented in the SAP software, referred to as “Customer Replenishment Planning” (CRP). In Figure 3 we show a graph of the shipments from the production facility to the distribution centre of a retailer (for one specific product) in the pre-CRP period (2001-mid 2002) and the shipments in the post-CRP period (mid 2002-2005). The coefficient of variation of the shipment quantities went down from 1.14 to 0.45 (a number observed for other products as well). We were also able to collect (post-CRP) data on the shipments from the distribution centre of the retailer to the different retail outlets. For the specific product discussed above, we obtain a coefficient of variation of 0.40.

The company now benefits from a higher flexibility in its production planning, since the CRP program allows to plan proactively instead of reactively. It is also able to utilize the production facilities more efficiently, as the outputs need not be ramped up and down based on large swings in orders. It reduced its transportation costs considerably due to an improved and more stable transport planning. Moreover, inventories decreased both at the manufacturer and at the retailer,

FIGURE 3
The impact of VMI on the order variability



improving the freshness of the products of the end consumer. Finally, the customer service level improved as product availability increased, thereby increasing the profitability for both the manufacture and the retailer.

IV. CONCLUSION

Altruistic behavior refers to the act of self-sacrifice for the benefit of others. In this article we didn't refer to the ethical interpretation, but simply to the idea that in supply chains the optimal global performance is not obtained by optimal behavior of the individual players. Or stated more simply, inefficiencies creep in when rational members of supply chains optimize individually instead of coordinating their efforts. We show that coordination creates a supply chain gain. This gain has to be allocated to the players so that each firm's objective becomes aligned with the supply chain's objective. Self-sacrifice is in other words not what happens. Instead, the altruistic behavior has to be compensated by buy-back contracts, revenue-sharing contracts, quantity flexibility contracts, sales rebate contracts, shorter lead-times, information sharing, collaborative forecasting or vendor managed inventories. In this article we discuss and summarize the most important supply chain coordination mechanisms.

ACKNOWLEDGEMENTS

This research contribution is supported by contract grant G.0051.03 from the Research Program of the Fund for Scientific Research – Flanders (Belgium) (F.W.O.-Vlaanderen).

REFERENCES

- Bernstein, F., Chen F. and Federgruen A., 2006, Coordinating Supply Chains With Simple Pricing Schemes: The Role of Vendor-Managed Inventories, *Management Science*, 52(10), 1483-1492.
- Balakrishnan, A., Geunes, J. and Pangburn, M., 2004. Coordinating Supply Chains by Controlling Upstream Variability Propagation. *Manufacturing & Service Operations Management*, 6(2), 163-183.
- Boute, R., 2006, The Impact of Replenishment Rules with Endogenous Lead Times on Supply Chain Performance, Ph.D. Thesis (Faculteit Economische en Toegepaste Economische wetenschappen, K.U.Leuven), 180 pp.

- Cachon, G., 2003, Supply Chain Coordination with Contracts, in de Kok, A. and Graves, S., ed., *Supply Chain Management: Design, Coordination and Operation* (Elsevier, Amsterdam), 229-339.
- Cachon, G. and Terwiesch, C., 2006, *Matching Supply with Demand*, McGraw-Hill International Edition, 434 pp.
- Chopra, S., and Meindl, P., 2007, *Supply Chain Management: Strategy, Planning & Operation*, Pearson Prentice Hall (third edition), 536 pp.
- Dejonckheere, J., Disney, S.M., Lambrecht, M.R. and Towill, D.R., 2003. Measuring and Avoiding the Bullwhip Effect: A Control Theoretic Approach. *European Journal of Operational Research*, 147, 567-590.
- Disney, S.M., Farasyn, I., Lambrecht, M.R., Towill, D.R. and Van de Velde, W., 2005. Smooth is Smart: Bullwhip, Inventory, Fill-rates and the Golden Ratio. *Tijdschrift voor Economie en Management*, vol. L, no. 2 (Febr.), 167-185.
- Disney, S.M., Farasyn, I., Lambrecht, M.R., Towill, D.R. and Van de Velde, W., 2006. Taming the Bullwhip whilst Watching Customer Service in a Single Supply Chain Echelon. *European Journal of Operational Research*, 173, 151-172.
- Disney, S.M., Lambrecht, M., Towill, D.R., Van de Velde, W., 2007. The Value of Coordination in a Two Echelon Supply Chain: Sharing Information, Policies and Parameters, *Working paper KBI 0701*, Department of Decision Sciences and Information management K.U.Leuven, 26 pp (to be published in IIE Transactions 2007).
- Forrester, J. (1961). *Industrial Dynamics*. MIT Press, Cambridge MA.
- Holweg, M., Disney, S., Holström, J. and Smaros, J., 2005, Supply Chain Collaboration: Making Sense of the Strategy Continuum, *European management Journal*, 170-181.
- Lambrecht, M., 2006, *Handboek Productie- en Logistiek Management*, Alta, 590 pp.
- Lee, H.L., Padmanabhan, V. and Whang, S., 1997. The Bullwhip Effect in Supply Chains. *Sloan Management Review*, Spring 38(3), 93-102.
- Munson, C.L., Hu, J. and Rosenblatt, M., 2003, Teaching the Costs of Uncoordinated Supply Chains, *Interfaces*, 33 (3), 24-39.
- Tsay, A., Nahmias, S. and Agrawal, N., 1999, in Tayur et al., *Quantitative Models for Supply Chain Management* (Kluwer Academic Publishers), 299-336.

